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Original Article

Decadal characteristics of small-scale fishing livelihoods in 13 Pacific Island Countries and Territories

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Small-scale fisheries are cornerstones of wealth, food, and tradition for people throughout the Pacific region. Yet, their governance is plagued by a lack of relevant data. Using data collected from household income and expenditure surveys carried out in 13 Pacific Island Countries and Territories over the last decade, we bring enhanced resolution to these fisheries by describing how households engage in small-scale fishing and accounting the income generated from these activities. We find most households do not actively participate in fishing, and most that do, fish only for subsistence. Over time, however, the rates at which households participate in fishing may be declining. Further, the total income generated through aquatic foods caught for subsistence is nearly double that of foods caught for sale, but on a per household basis fishing for commercial purposes is more lucrative. Differences point to important distinctions in how households engage with and generate income from commercial and subsistence fishing, including where activities are often conducted, and the types of aquatic foods targeted. These distinctions have implications for how livelihoods-focused policies and programmes can be developed to ensure aquatic food systems continue to support Pacific Island communities as the deadline for the Sustainable Development Goals approaches.

Keywords: aquatic foods, census survey, livelihoods, Pacific, rural development, small-scale fishery..

Introduction

The ocean is a significant source of cultural identity for people in the Pacific Island region, and fisheries are a salient feature of wealth, food, and tradition (Johannes, 1997; Hau'ofa, 2008). Fishing supports an array of livelihoods, which power village economies and supply the region with a diversity of nutritious aquatic foods. These aquatic foods account for the majority of animal-sourced protein consumed in the region (Dalzell *et al.*, 1996; Charlton *et al.*, 2016; Gillett, 2016; Farmery *et al.*, 2020). The complex tenure and taboo institutions that preside over fishery resources have helped shape societies by managing relationships among social groups for centuries (Ruddle, 1988; Foale *et al.*, 2011). Fisheries also play an integral role in preparing for, coping with, and recovering from natural disasters and economic shocks, including the COVID-19 pandemic (e.g. Eriksson *et al.*, 2017; Steenbergen *et al.*, 2020; Ferguson *et al.*, 2022). Securing a sustainable supply of aquatic foods is therefore a priority for Pacific countries, as seen in the numerous declarations towards this goal in recent years (e.g. FFA & SPC, 2015; SPC, 2015).

Most aquatic foods in the Pacific are harvested from the wild rather than grown. Vessel size and the type of gear used are most frequently used to distinguish between large-scale industrial fisheries and small-scale fisheries, yet how or where to draw the line has been a debated topic for decades due to the diversity and complexity of small-scale fisheries (e.g. Chuenpagdee *et al.*, 2006; Johnson, 2006; Smith and Basurto, 2019). While a broad range of dimensions can help holistically classify a fishery along a continuum of operational scale (see Westlund *et al.*, 2023), for the purpose of this study, we focus on their dimensions of production and distribution to classify them based on recent scholarship from the Asia-Pacific region (e.g. Teh and Pauly, 2018; Fabinyi *et al.*, 2022).

Small-scale fisheries can be socially and economically organized as a part of household livelihood portfolios. Livelihoods in this case can be broadly understood to consist of the portfolio of activities, assets, and access to these that together support people's lives (Ellis, 2000). While most of the catch from industrial fishing is destined for international markets and provides little direct benefit to local communities (Gillett, 2016), landings from small-scale fishing are often consumed at home or exchanged, bartered, or sold at local markets. Most of the economic, nutritional, and cultural benefits derived from fisheries by Pacific Islanders come from these small-scale fisheries (Teh and Sumaila, 2013; Gillett and Tauati, 2018).

Despite rich scholarship detailing the indispensable value of small-scale fisheries in the region, their governance is plagued by a lack of relevant data (King and Lambeth, 2000). In sharp contrast with industrial fisheries, where the statistical systems monitoring their catch, effort, and economic contributions are well established (e.g. Terawasi and Reid, 2017; Brouwer *et al.*, 2018), the statistical systems for small-scale fisheries are typically absent, incomplete, or inaccurate (de Graaf *et al.*, 2011). Catches are often unaccounted for in official statistics, resulting in an underestimation of their contribution to national economies and food systems (Zeller *et al.*, 2007; 2015). Reliable information on participation in fish-based livelihood activities across the region also remains scarce (Kittinger, 2013; Connell, 2018), particularly for women (Chapman, 1987; Harper *et al.*, 2013). In sum, these information gaps impede

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evidence-based planning and decision-making for sustainable fisheries management and development (Houk *et al.*, 2012; Teh and Sumaila, 2013; Connell, 2018).

The relative lack of data on small-scale fishing practices is indicative of the difficulty in gathering it. In addition to being diverse and complex, small-scale fisheries are also highly dispersed and often in remote locations. This makes data collection expensive and technically challenging, and requires human resources, which are limited in many national and regional agencies (Johannes, 1998; Zeller *et al.*, 2015). As a more cost-effective approach, recent literature has highlighted the potential of household income and expenditure surveys (HIES) to fill this information gap (e.g. Bell *et al.*, 2008; 2009; de Graaf *et al.*, 2011; Zeller *et al.*, 2015). Bell *et al.* (2008) specifically proposes that HIES should be modified to capture the contribution small-scale fisheries make to livelihoods in the Pacific region by quantifying the number of households engaged in commercial and subsistence fishing, and the earnings made from different fishing activities. How people participate and draw income from fishing activities can serve as proxies for how livelihoods are constructed in regional aquatic food systems.

During the last decade, HIES protocols have been updated offering a unique opportunity to better describe characteristics of small-scale fishing activities. Utilizing data collected from these modified HIES, we aim to provide a snapshot of household participation in small-scale fishing livelihood activities from across the Pacific and to quantify the economic value generated from these activities. To do so, we ask the following questions: (1) How do households engage in small-scale fishing activities throughout the region, and (2) what contribution do small-scale commercial and subsistence fisheries make to annual household income? To answer these questions, we first report on the number of households that actively fish in both urban and rural areas, including those that sell their catch. We also examine what habitats are fished and what gears or methods households most frequently utilize to conduct these activities. We then account the income generated through fishing for commercial or subsistence purposes and investigate differences between the aquatic foods caught while fishing for these different purposes.

Although the role of small-scale fisheries in sustainable development is widely acknowledged in regional policy (e.g. FFA & SPC, 2015; SPC, 2015), there remains a need for enacting policies and implementing programmes that optimize the multifaceted benefits communities draw from them. By bringing enhanced resolution to these historically data-poor fisheries, we intend to contribute to a more precise understanding regarding how fishing fits within Pacific Island livelihoods. Synthesizing how people engage with, generate economic value from, and utilize aquatic food system resources produces important insights for actors and institutions working in the region to advance policies, set development agendas, or fund projects and programmes. Incorporating these insights into their planning can help identify where livelihoods-focused efforts to progress desirable fisheries and development outcomes may have the most impact. This has implications not only in the Pacific but also globally to increase the contribution of small-scale fisheries towards global development goals and help monitor food system transformations towards these commitments (see Fanzo *et al.*, 2021; Westlund *et al.*, 2023).

Methods

National-level data were collated from HIES in 13 Pacific Island Countries and Territories (PICTs) over much of the last decade, from 2012 to 2019 (Figure 1). The survey statistics, including year of survey sample, total households sampled, and proportion of rural and urban households, are summarized in **Supplemental Information**. Estimates derived from each survey are scaled to a national level consistent with the survey design.

While we report on the unit of the household, each national-level survey collected household data with questions framed around individual members of the household. In this case, a member of the household refers to someone who usually stays in the house, including temporary members and members that are temporarily away if they intend to return. In tables and figures, we refer to PICTs by their International Organization for Standardization code: Cook Islands (COK), Federated States of Micronesia (FSM), Kiribati (KIR), Marshall Islands (MHL), Niue (NIU), Nauru (NRU), Palau (PLW), Solomon Islands (SLB), Tokelau (TKL), Tonga (TON), Tuvalu (TUV), Vanuatu (VUT), and Samoa (WSM). In the following sections, we summarize our methodology for extracting, organizing, and analysing the national-level HIES data.

Household participation in small-scale fishing

Households were identified as a fishing household if any member of the household conducted a fishing activity within the timeframe that each national-level survey was carried out in, irrespective of whether the activity was conducted as a one-off or on a regular basis. We focus specifically on participation in capture fishing in marine environments, including coastal gleaning, but excluding participation in aquaculture and inland (freshwater) fishing activities. Participation in fishing activities is differentiated from participation in the fisheries sector, which also includes wage work and post-harvest activities. While we do not report on household participation in the broader fisheries sector, we do identify households that both participated in fishing and sold some or all their catch.

For households participating in fishing, activities were categorized according to the habitat type fished and the gear used. Six habitats were recognized: "beach and lagoon," "mangrove," "coastal reef," "outer reef," fish aggregating device—"FAD," or "offshore." Similarly, we categorize six gears and methods, including "gleaning and diving," "traps," "spear," "net," "hook and line," or "longline and bottom" fishing. All households that were identified as participants conducted a fishing activity in one or more of these locations using one or more of these gears or methods.

There were inconsistencies in how the data for fishery participation was captured between PICTs. In ten of the 13 PICTs, household participation was recorded over a 3-month period, but for the other three PICTs that were surveyed in 2019, the HIES protocol changed so that participation was recorded over a 7-day period. To account for this, we first standardized the unit of time among the national surveys and then annualized the participation statistics to report on total participation in small-scale fishing. Another inconsistency related to how participation data was coded. For example, the Cook Islands survey only provides one general variable for the activity of spearfishing, but the Marshall Islands survey differentiates between spearfishing at day and night. We

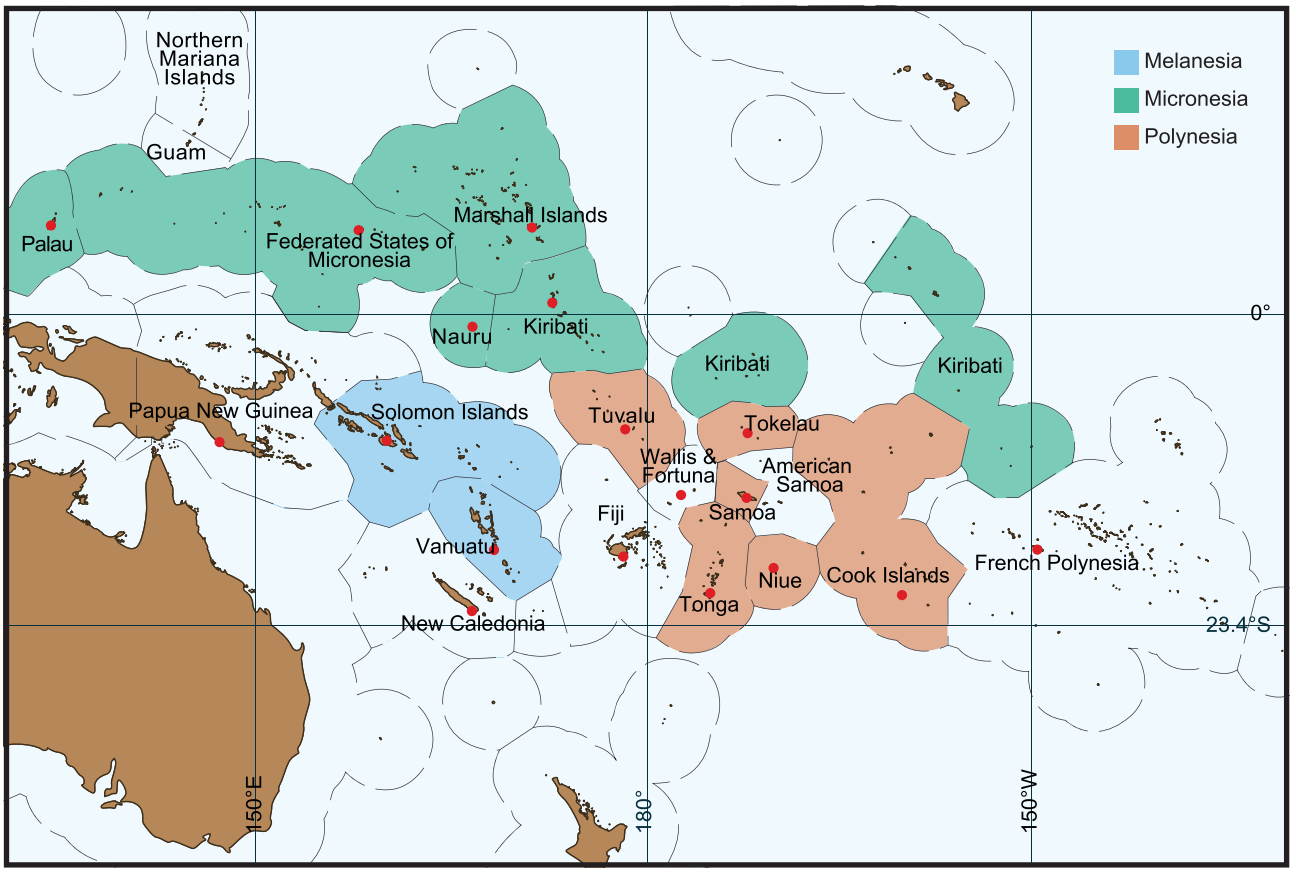

Figure 1. Geographical representation of the Pacific region with the 13 PICTs we report across highlighted by sub-region. Red dots indicate the approximate location of each PICTs administrative capital.

therefore had to harmonize common variables into fitting categories across the national-level surveys. For a breakdown of how these variables were grouped into the categories we report on, see Supplemental Information.

Participation correlation

We also explore the relationship between household participation and the economic development of each PICT. We do so by testing how they are correlated and use human development index rankings as a proxy for economic development (UNDP, 2022). Prior to the correlation analysis, a Shapiro–Wilk test was performed to check the normality of the data, which confirmed the Pearson's correlation method to be the most appropriate.

Household income from small-scale fishing

For each PICT, we report on household income from fishing of all surveyed households in the local currency as it was recorded during the implementation of each national survey. To include the different sources of economic value that fishing households generate through fishing, we adopt a broad definition of the word income. Thus, household income from fishing encompasses the economic value of aquatic foods caught and sold, home-produced (and consumed), or received as gifts.

We report household income from fishing as a percentage of total annual household income for all surveyed households and then specifically for households that fish. To conduct the calculation for only households that fish, we isolated the households that generated fishing income and then summed their total annual income. Total annual household income incorporates all income generated by a household and its members from all livelihood sectors (e.g. agriculture, fishing, wages, and salaries, remittances, etc.). For other primary activities such as agriculture, livestock, and handicrafts, we use the same approach to calculate income as we do for fishing, so that total annual household income also captures the value of goods home-produced or received as gifts from these sectors. Annual household income statistics for all households and specifically for fishing households are summarized in Supplemental Information.

We also differentiate income generated through commercial and subsistence small-scale fishing. For commercial fishing income, we use the "value of cash sales" (i.e. the gross cash value of aquatic foods caught and sold by the household) as a proxy. For subsistence fishing income, we use the sum of the "value of home production" (i.e. the gross cash value of aquatic foods caught and consumed by the household) and the "value of gifts" (i.e. the gross cash value of aquatic foods gifted to the household) as a proxy. Some national-level surveys separate the value of aquatic foods received in bartering; however, due to the limited availability of these data, we combined this source with the value of gifts received.

While discussing income from subsistence fishing may appear paradoxical from different perspectives, our adoption of this economist perspective is a consequence of how the income aggregate is constructed in regionally standardized HIES

methodology. Data from both the income and expenditure modules are utilized to account for cash receipts from the sale of aquatic foods in the income dataset and the home-produced and in-kind receipts of aquatic foods in the expenditure dataset. These two modules slightly differ among national surveys in how data are collected. Specifically, the income module captures the value of cash sales in the last 30 days, while the expenditure module captures the value of home production and gifts in the last seven or 14 days. Similar to the household participation statistics, we standardized the unit of time between the modules and then annualized the raw income and expenditure data to report on annual household income from small-scale fishing activities.

Household income from aquatic food categories

Small-scale fishing households generate income from various aquatic foods. To capture this, we disaggregated aquatic foods into six categories and reported on their proportional monetary contribution to each of the three sources of income.

During implementation, national HIES classified goods into product types using the United Nations Statistical Division's Classification of Individual Consumption According to Purpose codes (COICOP). The codes used to classify similar goods in each national survey are typically inconsistent and differed between income and expenditure modules. We, therefore, harmonized common variables to create six aquatic food categories. The examples provided in the list of categories below are not exhaustive; see **Supplemental Information** for the full set and original COICOP codes.

1. **Pelagic**—including tuna, bill fish, and wahoo and coastal pelagic species such as trevally and mackerel.
2. **Reef**—including grouper, snapper, and parrot fish.
3. **Invertebrate**—including shellfish, sea cucumbers, cephalopods, and arthropods.
4. **Deep sea**—deep sea fish species such as red fish.
5. **Unspecified**—mixed and uncoded finfish.
6. **Other**—other seafoods including turtles, sharks, milkfish, and aquatic plants.

Data access and analysis

Access to national survey data was granted through a memorandum of understanding between the Pacific Community and the national statistics office of each PICT. Analysis and data visualization were conducted in RStudio (RStudio Team, 2020).

Limitations and caveats

The HIES data depicts national statistics. Although broad characteristics and trends in fishing practices can be deciphered at this level, it can also lead to generalizations that do not reflect the highly contextual realities of people throughout the region. Further, we report HIES data from across 13 PICTs, which means there are several PICTs not represented in our analysis, notably Papua New Guinea and Fiji. These countries are the two biggest contributors to small-scale fisheries production in the Pacific (see Gillett and Tauati, 2018). Therefore, while we speak generally about PICTs, we acknowledge the absence of these significant producers.

By reporting at the unit of the household, we lose granularity provided by intra-household dynamics such as differences in women's and men's division of labour (e.g. de la Torre-Castro *et al.*, 2017). Although reporting at this level limits our ability to examine intra-household dynamics, the national-level surveys framed their questions around individual members of the household. Consequently, we can still capture the livelihood contributions of all household members, which represents an important step in recognizing and quantifying the significant role of women in fisheries (Harper *et al.*, 2013).

There were also discrepancies within the data between analogous variables; particularly relating to subsistence fisheries where the catch does not enter any formal marketplace. For example, the data for households that participate in subsistence fishing and the data for households that generate income from subsistence fishing often do not match each other. It is therefore possible that the HIES data undervalues participation in, and value generated through, subsistence fishing. It is also likely that the anecdotal percentage of Pacific Islanders that participate in fishing is higher than what we report. We recognize these limitations and caveats of using HIES data to report on household participation in and income from fishing activities, but contend these data represent an important and underutilized source of knowledge to help fill the gap in our understanding of small-scale fisheries throughout the Pacific region.

Results

Household participation in fishing

Although highly variable, across the region, 32% of households participate in small-scale fishing activities (Figure 2). The highest participation rates were observed in Tokelau (75%), Tuvalu (54%), and the Solomon Islands (48%). Although in the small island nation of Tokelau this only corresponds to roughly 200 fishing households, in the Solomon Islands the number of households that fish is two orders of magnitude larger, at ca. 50000 households. Conversely, the lowest participation rates in fishing activities were observed in Nauru (7%) followed by Palau (11%).

Most participating households come from rural areas in nearly all PICTs that differentiated between urban and rural in their sampling. This includes over 90% of household participation coming from rural households in the Solomon Islands, Tonga, Vanuatu, and Samoa. Only in Palau (73%) did the majority of household participation in fishing come from urban households. Similarly, in nearly all surveyed PICTs, most fishing households do not sell part or all of their catch. For example, in the Cook Islands (11%), Tokelau (12%), Niue (15%), and Tuvalu (18%) <20% of fishing households sell their catch. Therefore, in these PICTs over 80% of households that fish do so only for subsistence. There were only two exceptions where the percentage of fishing households that sell some or all of their catch was the majority: Nauru, where 100% of fishing households also sell catch, and in the Solomon Islands, where 61% of fishing households also sell catch.

Nine of the surveyed PICTs were ranked in the latest human development index (UNDP, 2022). Six of which are categorized as having "medium" human development, while the other three have "high" human development. Although not statistically significant, there was a moderate

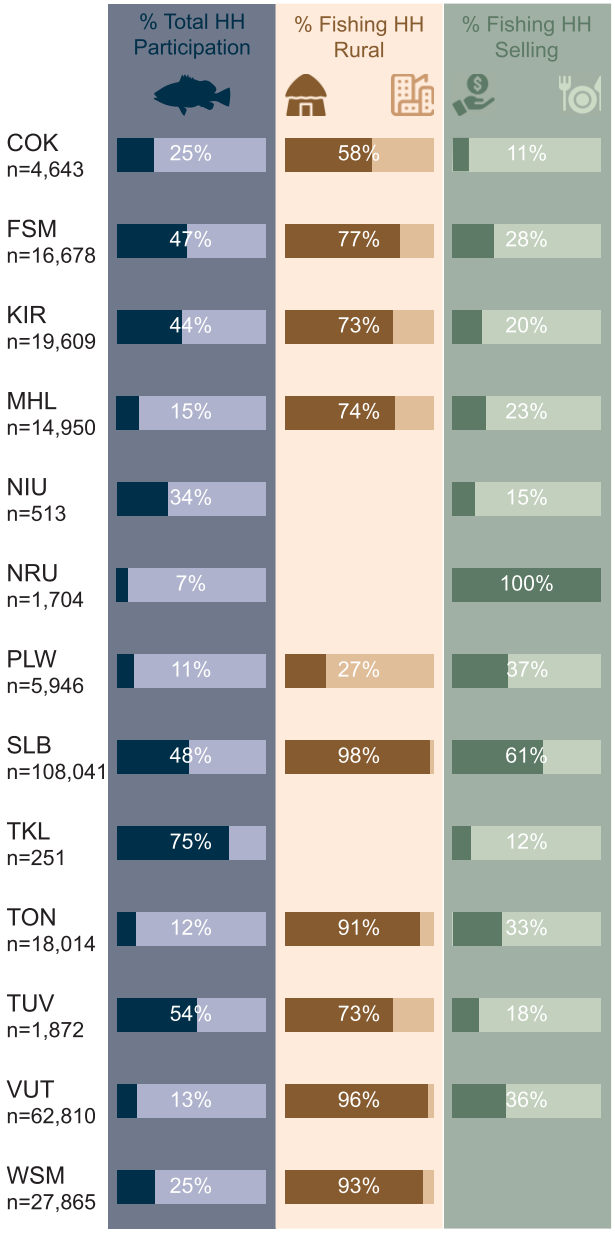

Figure 2. The percent of total sampled households (HH) that participate in small-scale fishing (blue), as well as the percentage of fishing households coming from rural environments (brown), and the percentage of fishing households that sell some or all their catch (green). Note: NIU, NRU, and TKL did not differentiate between urban and rural households in their sampling, and there were no data on households that sell fish in WSM.

correlation between participation rates in fishing and the human development index ranking of each PICT (Pearson correlation coefficient = –0.6; $P = 0.087$; Figure 3).

Most fishing was done in inshore habitats such as beaches and lagoons and coral reefs (Figure 4). Specifically, the beach and lagoon averages 54% across all fishing households, followed by coastal reefs at 49%. Five of the nine PICTs with data on household participation in different habitats had the highest percentage of participation in beach and lagoon habitats, including Tokelau (76%), the Marshall Islands (72%), and Tonga (71%). The other four PICTs all had the highest percentage of participation in coastal reefs, including Niue (75%) and the Federated States of Micronesia (71%). Only

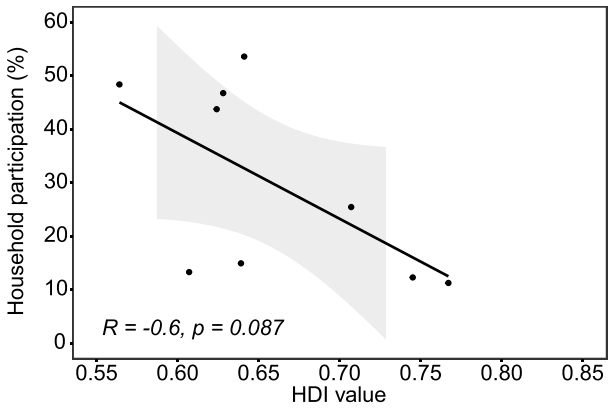

Figure 3. Pearson's correlation between household fishing participation rates in nine of the sampled PICTs and their human development index (HDI) ranking.

two of the surveyed PICTs had household participation rates at or above 50% in offshore environments, Tokelau (74%) and Palau (50%). The least utilized habitats were FADs and mangroves, which both averaged just under 10% for all PICTs with data. Niue (22%) had the highest participation rate at FADs, while Palau (22%) had the highest participation rate in mangroves.

Hook and line gears were the most utilized in five of the ten PICTs with these data, most notably in Tokelau (88%) and Niue (83%; Figure 5). Across all PICTs, this gear averaged the highest percentage of utilization in 50% of fishing households, followed by the use of nets (41%). While only six PICTs collected data on longline and bottom fishing, fishing household participation with this gear averaged 33% across them. Gleaning and diving averaged 28% across the ten PICTs and is particularly utilized in Niue (72%) and Palau (48%). Spearfishing was not as heavily practiced throughout the region compared to other gears and methods, but in Federated States of Micronesia (67%) and Palau (53%), it was the most utilized gear for fishing households. Traps were the least utilized gear, averaging only 2% across PICTs with these data.

Household income from fishing

Income from fishing varied among the enumerated PICTs, but for all surveyed households, it averaged just 3.8% of total annual household income (Table 1). The highest percentage of income generated from fishing was in Kiribati (7.9%), followed by the Solomon Islands (6.9%), while the lowest percentages were in the Cook Islands (1.3%) and Palau (1.4%). Only counting the income from households that fish, the percent of total annual income that fishing contributes still only averages 9.9%. These percentages were highest in Tonga, Vanuatu, and the Solomon Islands, where fishing accounts for 17.2, 14.8, and 13.9% of total annual household income in fishing households, respectively. For some PICTs (e.g. Tokelau), there was only a minor difference in the percentage of income generated from fishing between all households and fishing households, yet in Tonga, the contribution of fishing rose from 1.7% to 17.2% of total annual household income.

There was a general trend among fishing households to generate more income on a per household basis from fishing for

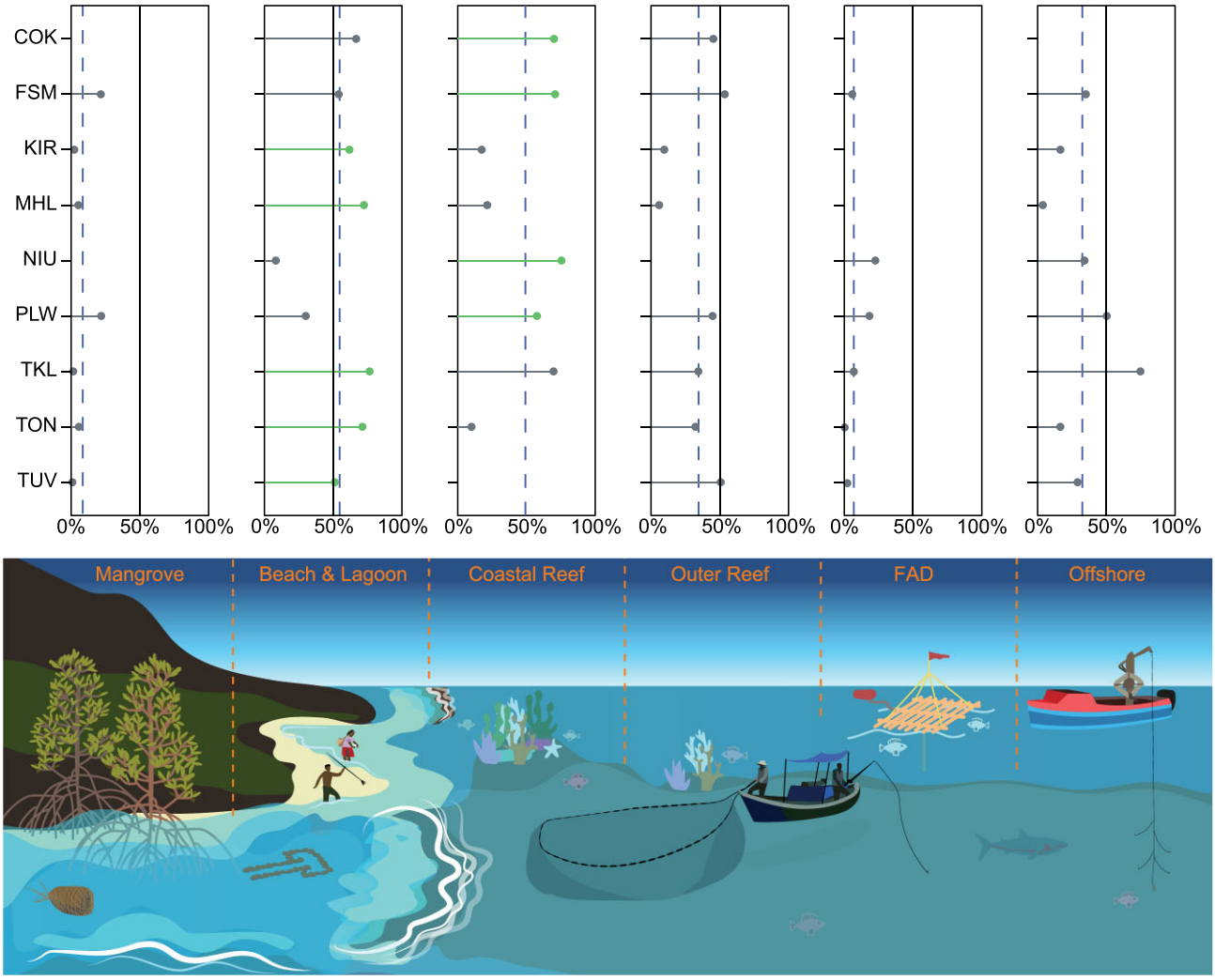

Figure 4. Fishing household participation (%) in various seascape habitats. Green segments indicate the most utilized habitat for that PICT. Blue dotted lines represent average use across all PICTs with data for that habitat. Note: There were no data on household participation by habitat for NRU, SLB, VUT, or WSM.

commercial purposes compared to fishing for subsistence. For example, commercial fishing households in the Cook Islands generated on average NZD 10050 from the aquatic foods they caught and sold compared to subsistence fishing households, which consumed catches to an equivalent value of NZD 2206. The exceptions to this are in Tokelau and Niue, where subsistence fishing households generated more income from their catch than commercial fishing households on a per-household basis.

When differentiating between the three types of income, the value of home-produced and consumed aquatic foods accounted for the highest percentage of total fishing income in 8 of the 12 PICTs with this data (Figure 6)—including Federated States of Micronesia (64%), Tuvalu (64%), and Tokelau (64%). Overall, this type of income accounted for an average of 47% of the total fishing income across all PICTs. Three PICTs had the highest percentage of total fishing income coming from cash sales, including Tonga (68%), Kiribati (44%), and Cook Islands (43%). Only in Nauru was the highest percentage of total fishing income derived from the value of gifts received (44%).

Households generated fishing income from diverse categories of aquatic food groups, and these categories differ between types of income. For commercial fishing income, which corresponds to the value of aquatic foods caught for cash sales, nearly half of the PICTs generate the largest percentage of this income source from pelagic fish species (Figure 7a), including Tokelau, where 100% of cash sales income was from pelagic fish, and the Cook Islands, where 90% was from pelagic fish. Across all PICTs, the average commercial fishing income generated from pelagic fish is 47%. Several PICTs also generated the largest percentage of commercial fishing income from reef fish species, including the Marshall Islands (75%) and Palau (60%). The only two PICTs that do not generate the largest percentage of commercial fishing from either of these aquatic food categories were Niue (41% from invertebrates) and the Solomon Islands (28% from deep sea fish species).

For subsistence fishing income, which is the sum of the value of aquatic foods caught and consumed by the household (home production) and the value of aquatic foods received as gifts, two-thirds of the PICTs generated the highest percentage of this income source from reef fish species (Figure 7b). This includes seven PICTs where the percentage of home

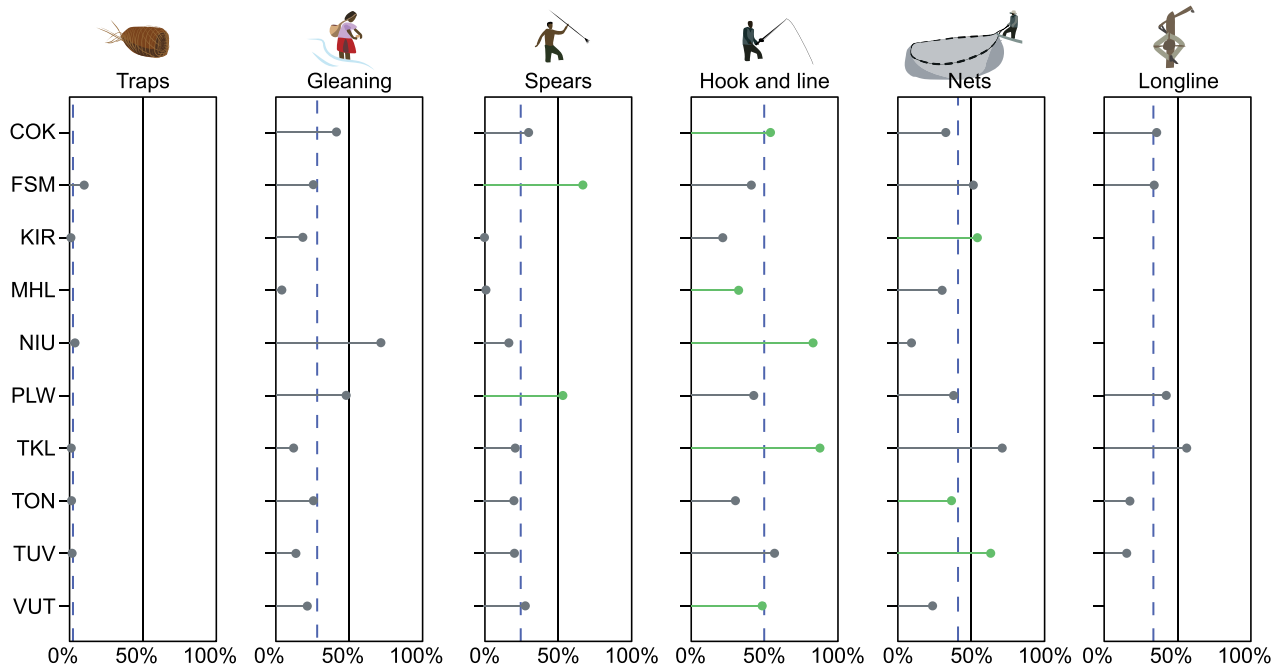

Figure 5. Fishing household participation (%) using different gears or methods. Green segments indicate the most utilized gear for that PICT. Blue dotted lines represent average use across all PICTs with data for that gear. Note: There were no data on household participation by gears and methods for NRU, SLB, or WSM.

Table 1. Income generated from small-scale fishing as reported in each PICT's local currency.

PICT (currency)	Annualized fishing income[a]	Percent of total income (all HH)[b]	Percent of total income (only fishing HH)[b]	Average income per fishing HH (commercial)[c]	Average income per fishing HH (subsistence)[c,d]
COK (NZD)	2,960,716	1.26%	10.18%	10,050	2,206
FSM (USD)	12,477,911	4.41%	9.03%	1,535	862
KIR (AUD)	25,915,026	7.91%	11.23%	6,613	969
MHL (USD)	6,334,358	2.01%	6.00%	4,153	890
NIU (NZD)	376,212	1.60%	7.47%	1,601	2,317
NRU (AUD)	1,637,871	2.61%	4.64%	3,597	1,238
PLW (USD)	2,077,840	1.37%	3.51%	3,232	621
SLB (SBD)	503,967,557	6.92%	13.90%	6,685	4,155
TKL (NZD)	416,600	5.84%	7.10%	603	1,564
TON (TOP)	9,699,291	1.65%	17.21%	9,078	1,286
TUV (AUD)	1,539,309	5.11%	13.57%	2,274	1,291
VUT (VUV)	4,109,074,698	5.35%	14.77%	480,940	108,450
WSM (SAT)	n/a	n/a	n/a	n/a	n/a

For each location, we describe the percent of total annual income that fishing contributes for all households (HH) and specifically for fishing households. We then calculate the average income that fishing households make from commercial and subsistence fishing. Although WSM is included in the table, there is no data for income generated from fishing.
[a]Annualized fishing income is the sum of the value of cash sales, value of home production, and the value of gifts received.
[b]See Supplementary info for annualized income statistics.
[c]Calculated using the income aggregate data so that average commercial or subsistence fishing income is per commercial or subsistence fishing household.
[d]Excluding the value of aquatic foods received as gifts because households do not need to actively fish to generate this type of income. Therefore, subsistence income in this calculation only includes the value of home-produced aquatic foods.

production income from reef fish was above 50%, led by Federated States of Micronesia (70%) and Niue (63%). Across the surveyed PICTs, the average subsistence fishing income generated from reef fish is 47%. Comparatively, the average percent of subsistence fishing income generated from pelagic fish species is approximately half of its average percent of commercial fishing income at 25%. Still, a few PICTs generated their largest percent of subsistence fishing income from pelagic species including Nauru (53%), Kiribati (51%), and Tokelau (50%). Tonga is the only PICT where the largest percentage of subsistence fishing income comes from other seafood (51%).

Discussion

Fishing participation

Fishing is a significant source of livelihood for many throughout the region as a component of diverse and dynamic household livelihood strategies (Kronen and Bender, 2007; FAO, 2014; Sulu *et al.*, 2015). The household participation rates observed in the 13 PICTs in our study echo this understanding; most surveyed households do not actively participate in fishing. For the households that do actively fish, the majority do so only for subsistence, most frequently in coastal habitats such

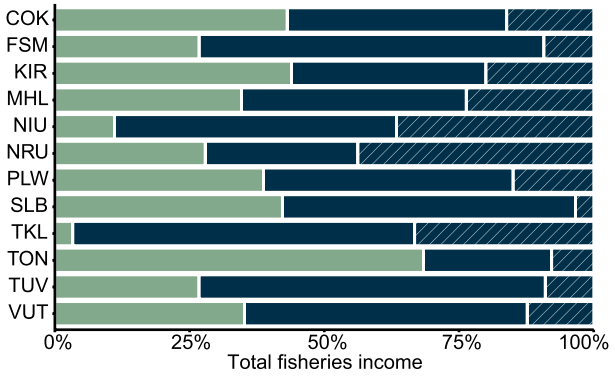

Figure 6. Percent of fisheries income generated through commercial fishing (green) and subsistence fishing (blue). Commercial fishing income is comprised solely from the value of cash sales, but subsistence fishing income is a combination of the value of home production (solid blue) and the value of gifts received (blue with white stripe). Note: WSM did not have data for income from fisheries.

as lagoons and inner reefs. These results are consistent with regional estimates that also report that the majority of people participating in small-scale fisheries are engaged in subsistence activities (e.g. Virdin *et al.*, 2023), and are unsurprising given that these easily accessible environments have historically provided the majority of aquatic foods caught by people for home consumption (Chapman, 1987; Dalzell *et al.*, 1996; Charlton *et al.*, 2016).

The decadal snapshot provided by HIES data illustrates several common threads in how households engage in fishing, but also key differences in fishing practices among the surveyed PICTs. Some differences are likely related to variations in local environmental characteristics. For example, variations in ecology and productivity surrounding local communities have been demonstrated to influence fishing practices (e.g. Smallhorn-West *et al.*, 2022). Economic development and livelihood opportunities in other sectors (particularly for subsistence) also likely impact fishery resource dependence or exploitation levels (e.g. Jennings and Polunin, 1996; Cinner *et al.*, 2005; Kronen *et al.*, 2010; Charlton *et al.*, 2016). This may partially explain the low participation rates in Palau, which was the only PICT with most fishing households coming from urban environments where access to a wider range of livelihood opportunities would be probable.

It would therefore be expected that less economically developed PICTs with limited cultivable land would have higher rates of fishing participation than those that are more developed or with more opportunity for agriculture. The moderate yet statistically insignificant correlation observed between household participation rates and the human development index rankings appears to broadly support this interpretation. Four of the six locations (the Solomon Islands, Kiribati, the Federated States of Micronesia, and Tuvalu), where household fishing participation is above the overall average (of 32%), had the lowest index ranking of the PICTs surveyed and are classified as countries with "medium" human development (UNDP, 2022). Two locations with above-average fishing participation (Tokelau and Tuvalu) are classified as "low" atoll islands (i.e. having an average island maximum elevation of under 30 m; Nunn *et al.*, 2016), where opportunities to generate subsistence from agriculture-based livelihoods would be limited. Marshall Islands and Vanuatu, however, stand as outliers with low participation rates and low index rankings. Perhaps uncoincidentally, both these PICTs were surveyed in 2019 after the HIES protocols to capture participation rates had been changed to shorter time frames. It is therefore possible that the participation rates for these two PICTs are underestimated.

Analysing changes in household participation rates over time is largely inhibited by the lack of comparable data, yet in the few instances where these data are available, fishing participation rates have declined. Statistics from census reports and previous HIES from 2009 to 2011 show household fishing participation rates in the Cook Islands (42% of households), Marshall Islands (49%), and Vanuatu (37%) were considerably higher than recorded in the most recent national household surveys (CISO, 2011; EPPSO, 2012; World Bank, 2014). Rates in Samoa from the 2009 census (25%) appear to remain relatively unchanged compared to the most recent HIES, although the census report also details that fishing participation declined substantially in comparison to both the 1989 and 1999 census (SBS, 2012). Some of this trend may be attributed to non-standardized methods and shifting definitions of what participation means within these surveys, but there is a precedent in the literature for a declining reliance on fishing in places where income is increasingly generated through salaried work (e.g. Charlton *et al.*, 2016).

Expectations about what people constitute as a satisfactory livelihood are evolving in the contemporary Pacific, shaped by large-scale processes such as climate change and the globalization of economic markets (Connell, 2015, 2018). The accessibility of education, health services, and formal employment opportunities have become valuable qualifications for a desirable occupation (Connell, 2018). Declining fishing participation rates are likely another effect of these processes, alongside increasing urbanization and reliance on associated remittances, as well as dependence on imported foods amid changing regional food systems (see Connell, 2015; Andrew *et al.*, 2022; Brewer *et al.*, 2023). Still, regardless of if they fish or not, evidence from around the region indicates that most households consume aquatic foods (e.g. Farmery *et al.*, 2020). Viewed through a food systems lens, the picture of how some PICTs have declining fishing participation rates, even with limited cultivable land and/or high rates of aquatic food consumption becomes clearer. More households are moving to urban and peri-urban centres and eating imported foods to meet dietary energy requirements, including both imported and domestically canned fish (Bell *et al.*, 2019; Andrew *et al.*, 2022).

The change from locally produced to imported processed foods (with the notable exception of canned fish) has been detrimental to the health and food security of Pacific Islanders (Hughes and Lawrence, 2005; Thow and Snowdon, 2010; Ferguson *et al.*, 2022). The impacts of climate change may further exacerbate regional food insecurity through declining fisheries and agriculture production, particularly for communities of low socioeconomic status (Barnett, 2011; Cinner *et al.*, 2022). However, population growth and associated demand for aquatic foods have already led to unsustainable pressure on coastal resources in some places, and the ability of these fisheries to meet the food security needs of Pacific Islanders is in question (Bell *et al.*, 2009; SPC, 2015). Livelihoods focused policies and programmes may therefore be unsuccessful to strengthen regional food security by increasing household participation in business-as-usual subsistence fisheries. Most households that already fish do so in coastal environments for

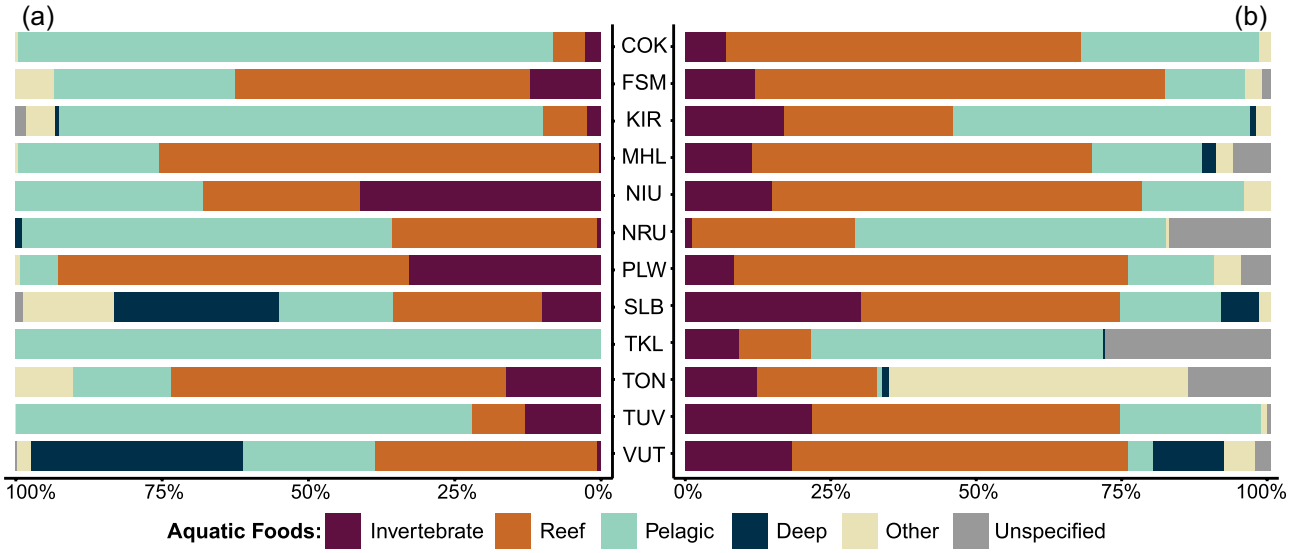

Figure 7. For each PICT, the percentage of (a) commercial fishing income and (b) subsistence fishing income generated from different aquatic food categories. Commercial fishing income is comprised solely from the value of cash sales, but subsistence fishing income is a combination of the value of home production and the value of gifts received. The sum of each horizontal bar equals 100% of the income generated through commercial or subsistence fishing in each PICT. Note: WSM did not have data for income from fisheries.

subsistence, and in some places these habitats are already exploited at high levels.

Diversifying into fish-based livelihood activities that operate in different ecosystems or target different resource functional groups may help prevent overexploitation of specific habitats or species (Roscher *et al.*, 2022a). In this regard, Bell *et al.* (2018) suggest transferring effort away from coastal environments by increasing participation in pelagic fisheries to maintain the contribution of aquatic foods to food security. Household participation rates of most PICTs in pelagic environments indicate these fisheries are underutilized in comparison to coastal habitats, likely due to their inaccessibility. Notably for islands with limited arable land and shallow reefs or without lagoons, increasing the accessibility of pelagic and coastal pelagic species has the potential to substantially contribute to local food security (Albert *et al.*, 2014; Bell *et al.*, 2015). Nearshore FADs are often promoted as a mechanism to enhance the accessibility of pelagic resources to small-scale fishers; however, evidence of their impact is obscure (Bell *et al.*, 2015; Gillett, 2022). Alternatively, small pelagic species are highly nutritious and resilient to overexploitation due to their life history characteristics, and there are instances around high islands where these fisheries have been a significant feature of local food and nutrition security (e.g. Roeger *et al.*, 2016).

Fishing income

The average contribution from fishing to total annual household income is not very high across the surveyed PICTs and averages just 10% of total income when only considering households that fish. Given the widespread acknowledgement of small-scale fisheries as a lynchpin in Pacific Island economies, this result is somewhat surprising (e.g. Gillett, 2016). Yet, it also seems to reflect the participation data and reinforce the notion that fishing is a component of diverse and dynamic livelihood strategies. Another similarity between the income and participation data relates to the largest percentage of total fishing income being generated through the value of aquatic foods caught for home consumption. Combined with the value of aquatic foods received as gifts, a regional average of two-thirds of the total income generated from fishing is for subsistence where the majority of fishing participation also occurs, compared to one-third for small-scale commercial purposes (via the value of aquatic foods caught and sold). This finding helps validate previous research estimating the economic value of subsistence fishing production to be higher than that of coastal commercial (e.g. Zeller *et al.*, 2007; Gillett, 2016).

While the regional average of total income generated through subsistence fishing is higher than that of commercial fishing, on a per-household basis, commercial fishing generates an average of approximately three-times higher income, including over seven-times higher in Tonga. Previous appraisals in the region have similarly estimated that the value at first sale of aquatic foods caught for commercial purposes is double that of aquatic foods caught for subsistence on a per kilogram basis (Gillett and Tauati, 2018). Fishing households generate income from diverse aquatic food categories, but perhaps these differences in economic value are indicative of the types of aquatic foods typically caught for sale versus consumed at home.

Nearly half of the commercial fishing income averaged across the region is from pelagic fish species, compared to under 25% of the subsistence fishing income. Reef fish species are also a large component of commercial fishing income, but their importance to subsistence fishing is comparatively much greater. Reef species account for the majority of subsistence fishing income in eight of the enumerated PICTs. This general pattern of pelagic fish being sold commercially and reef fish being consumed appears to be corroborated by literature from around the region. In Palau, Dacks *et al.* (2020) found that more than half of the landed reef fish were for subsistence compared to virtually none of the landed pelagic fish; and Sulu *et al.* (2018) reported that pelagic species accounted for 80% of the value of fish sold in a Solomon Islands fish market.

The combined results of higher income per household for commercial fishing households and the highest percentage of commercial fishing income being generated through pelagic fish lend themselves to the over-simplistic narrative that commercial fishers target pelagic fish because they have a higher economic value. However, the broad stroke of fishing characteristics provided in the national-level HIES data masks localized detail. Tendencies to catch, sell, or consume different aquatic foods would be highly contextual to local conditions. They would be mediated by the range of accessible environments that determine local resource availability, but particularly in the Pacific, they would also be influenced by social and cultural factors. To illustrate, in Malaita province of the Solomon Islands, rules based on traditional beliefs may restrict the consumption of certain marine species such as sharks and sea cucumbers, but these species can still be sold to generate cash income (e.g. Sulu *et al.*, 2015). Previous literature has also demonstrated that fishers are motivated by objectives outside of profit maximization, such as the ability to satisfy home consumption needs and fulfil social obligations, including acts of reciprocity (e.g. Iwakiri and Ram, 1984; Kronen, 2004).

Still, in many cases, the most likely explanation for commercial fishing households earning more money on a per-household basis coupled with pelagic fish accounting for the largest component of commercial fishing income is an economic one. Participating in this type of fishing typically entails a greater investment in physical assets, which would exclude most fishers. For the limited small-scale commercial fishers that can regularly access pelagic fish species, it remains a lucrative business. Labrosse *et al.* (2006) demonstrate this in a New Caledonian setting, where they found significant differences in the catch composition between subsistence and commercial fishing. Fishing capacity limitations led to subsistence fishers staying closer to shore, where they caught inshore species.

Profit maximization may not be the primary objective for many fishers, but external market forces still have an influence on the fishing characteristics observed in the HIES. Deep-bottom fish species account for a substantial component of commercial fishing income in Vanuatu, and this fishery is driven by tourist demand (VFD, 2016). International demand for highly commoditized invertebrates such as trochus and bêche-de-mer also likely drive the high percentage of commercial fishing income coming from this category in Niue and Palau. Not all invertebrates are commercial commodities; however, many are an essential component of regional food security (Chapman, 1987; Harper *et al.*, 2013). This is demonstrated by their large contribution to subsistence fishing income in the Solomon Islands and Tuvalu.

There are complex nuances between commercial and subsistence use of different aquatic foods that differ between contexts throughout the region. The HIES data represents an important step towards a better understanding of broad regional trends, but there are still significant data gaps. For instance, the prevalence of income pertaining to "unspecified fish" or "other seafood" is much higher in the informal economy of subsistence fisheries. Developing effective livelihoods-focused policies and programmes in the region hinges upon the knowledge of how households generate different forms of economic value from different aquatic food groups. How aquatic foods are typically utilized would undoubtedly require a different set of management strategies and the application of different leverage points. Integrating these considerations into policies and programmes at different scales can reduce the risk of promoting ill-fitting livelihood solutions that often hinder livelihood-focused investments (Roscher *et al.*, 2022b). This can help ensure that efforts benefit people in the way they intend, so as to support sustainable development.

Conclusion

The systems of producing and distributing aquatic foods are central to the Pacific way of life, and they are evolving. Evidence from around the region indicates most households consume aquatic foods, yet trends within the HIES data reveals that in some places participation in small-scale fishing may be in decline. This trend may relieve exploitation pressure in some coastal environments where participation is found to be generally higher, but what this means for regional food and nutrition security is uncertain. Rigorous monitoring is needed to help guide food system transformations in a way that supports healthy people and ecosystems (Fanzo *et al.*, 2021).

These data provide regional policy makers, scientific and technical agencies, and international donor organizations with a reference point for how households in the Pacific engage with and generate economic value from aquatic food systems. However, as the Pacific integration with global food systems continues to evolve and adapt to the uncertainties of climate change, fishing characteristics will also continue to change. To understand how these large-scale processes interact and influence regional fishing characteristics, data collected through HIES will continue to be important to enable longitudinal analyses.

On a more local scale, future research is needed to better understand the livelihood choices of coastal communities in the Pacific amid changing environmental and economic conditions. How do fishing households respond to increased urbanization, and the availability of imported foods, or altered weather patterns and local environmental conditions? What are the livelihood and food and nutrition security implications of this transition? These questions have significant implications for how policies and programmes in the region should be designed to account for the different opportunities and challenges facing coastal communities throughout the region. This is a significant research frontier for Pacific Island small-scale fisheries, particularly given the disproportionate representation of PICTs atop the list of the most at risk to natural disasters (Behlert *et al.*, 2020) or the most vulnerable to the impacts of climate change (Blasiak *et al.*, 2017).

The importance of small-scale fishing to local economies and food and nutrition security for coastal communities throughout the region is well documented (e.g. Dalzell *et al.*, 1996; Gillett and Lightfoot, 2001; Charlton *et al.*, 2016; Farmery *et al.*, 2020), and supports the prominent role aquatic food systems are propositioned to play to achieve several Sustainable Development Goals (see FAO, 2018). Impeding the ability to plan for how small-scale fisheries can help achieve these goals has been a lack of data describing them. The data contained in the HIES brings enhanced resolution to these historically data-poor fisheries and serves as an important resource for future research, as well as evidence-based planning and decision making.

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Supplementary Data

Supplementary material is available at the *ICESJMS* online version of the manuscript. The following supplementary material is available at *ICESJMS* online: survey statistics including year and total households sampled in each PICT, income statistics including total household income in each PICT, and details of how participation and aquatic food categories were processed in each PICT.

Conflict of interest

The authors have no conflicts of interest to declare.

Author contributions

All authors contributed to the conceptualization of the manuscript. M.R. led the writing and analysis with input from all authors. M.S. and O.M. implemented the HIES queries in compliance with SPC data access agreements with national agencies.

Data availability

Additional data supporting this manuscript are available as **supplementary material**. HIES data are held by The Pacific Community (SPC).

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